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ABSTRACT

The Navy Junior Reserve Officers Training Corps (NJROTC) provides high school students with academic training and military leadership experience. The academic portion of the program consists of a 4-year naval science curriculum that includes these subjects: naval history, sea power, maritime geography, navigation, citizenship, oceanography, meteorology, military justice, astronomy, naval operations, communications, and intelligence. Approximately 10 years ago, a computer-based NJROTC multimedia instructional system (NMIS) was developed in the NJROTC program at Sanger High School, California, to enhance the delivery of the curriculum. The components of the NMIS are an instructor's computer, a large television monitor in front of the classroom, and individual computers for 28 students; all are connected via a local area network. The system is used in course lecture, for reading materials, and for tests. An evaluation of the system at Sanger and Lemoore High Schools was conducted during a 10-week period in 1995, using pretests and posttests, focus groups with 124 students, interviews with instructors, and observations of classes. The results of the data compilation indicate that the NMIS has a positive effect on students' academic achievement and a time-saving effect on the instructors' workloads. It was recommended that the system be replicated in other schools and more extensive research be done. (16 references) (KC)

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EVALUATION OF THE NJROTC MULTIMEDIA INSTRUCTIONAL SYSTEM

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EVALUATION OF THE NJROTC MULTIMEDIA INSTRUCTIONAL SYSTEM

PHILLIP D. DEVIN
ABBY E. ROBYN

Prepared for the United States Navy

National Defense Research Institute

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PREFACE

The Navy Junior Reserve Officers Training Corps (NJROTC) provides academic instruction and leadership training to high school students. Approximately ten years ago, a computer-based multimedia instructional system was developed in the NJROTC unit at Sanger High School in California. Over the years, the system has been refined and it has been installed at other schools. Before determining whether to expand the use of the system to additional NJROTC locations, the Office of the Chief of Naval Education and Training (CNET) asked RAND's National Defense Research Institute (NDRI) to evaluate it.

This study was conducted at two high schools. It is an "exploratory" study in that pre-existing groups were used instead of randomly assigned groups, and tests were not conducted to determine whether the students, instructors and environmental factors at those schools are typical of NJROTC units. Consequently, the findings are informative, but they should not be generalized to other locations.

We found that students who used the system made greater academic progress than their peers who received traditional methods of instruction. During focus groups, students reported that classes using the system were better organized and more compelling than traditional classes. Instructors reported that the system reduced their workload and facilitated their ability to enhance the course.

This study suggests explanations for the apparent efficacy of the system. It also discusses the potential for extending the system beyond its current applications.

The work reported here was sponsored by CNET and was carried out within the Forces and Resources Policy Center of RAND's NDRI. NDRI is a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, and the defense agencies.

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SUMMARY

The Navy Junior Reserve Officers Training Corps (NJROTC) provides high school students with academic training and military leadership experience. The academic portion of the program consists of a four-year Naval Science curriculum that includes naval history, sea power, maritime geography, navigation, citizenship, oceanography, meteorology, military justice, astronomy, naval operations, communications, and intelligence. The Office of the Chief of Naval Education and Training (CNET) provides most of the course materials (i.e., instructors' guides, textbooks, audiovisual aids, and tests).

Approximately ten years ago, a computer-based NJROTC multimedia instructional system (NMIS) was developed in the NJROTC program at Sanger High School, Sanger, California, to enhance the delivery of the Naval Science curriculum. The system has undergone extensive and relatively continuous refinement since its inception, and it has been adopted by other schools.

THE NJROTC MULTIMEDIA INSTRUCTIONAL SYSTEM

Physically, the principal components of the NMIS are an instructor's computer, a large television monitor located at the front of the classroom, and individual computers for 28 students; all are connected via a local area network. Functionally, the system can be defined principally in terms of course lectures, reading materials, and tests.

During lectures, the system is used to present key points of the lesson via "Instructor's Notes," which are projected on the screen at the front of the room (in the manner that slides or transparencies are

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used in military briefings and during meetings in business and other organizations). The copy appearing on the instructor's computer screen includes "buttons" which, when clicked, activate auxiliary equipment (such as the laser disk player provided by CNET); in this manner, still pictures, moving pictures, graphics, audio clips, etc., are incorporated easily into the lecture. An abbreviated version of the Instructor's Notes appears on the students' screens, and they take notes by annotating that copy.

Students read course materials, such as the textbook, on their computer screen. The electronic version of the textbook has hypertext links to pictures, other graphics, and a glossary. A split screen is used during the reading sessions; reading material appears in a window on the left side of the screen; students take notes in a window on the right side.

The system also is used to administer tests. Tests can be given in a variety of formats including multiple choice, true/false, brief essay, and graphical (e.g., "Identify 'Country A' on the map displayed above."). The system informs students of the correct answer to a question when they finalize their response, and it gives them their score when they complete the exam. At the end of the exam period, the system prepares statistical reports for the instructor (e.g., results by student or by question, as raw scores, as percentages, and so forth).

It has been posited that the NMIS promotes student achievement and enhances their attitudes toward courses through mechanisms such as multiple representations of material, immediate feedback, and aids that facilitate note-taking. Similarly, system features that organize the lectures, integrate audio and visual aids, and score students' tests were posited to have a positive effect on the instructors' workload.

THE RESEARCH QUESTIONS

Before determining whether to install copies of the NMIS at additional NJROTC units, CNET turned to RAND's National Defense Research Institute (NDRI) to evaluate the system. We were asked to explore a number of topics, which we synthesized into three broad research questions:

- Does the system have a positive effect on students' academic achievement?
- What are the students' attitudes toward courses using the system?
- What effect, if any, does the system have on instructors' workload?

METHODOLOGY

We conducted this exploratory study at Sanger and Lemoore High Schools over a ten-week period during the fall term of the 1995–1996 school year. Because of logistical and time constraints, it was not feasible to assign students to experimental and control groups. However, naturally occurring comparison groups were identified in three courses. Each of those courses consisted of multiple sections to which students had been assigned before the start of the study. Some sections used the system and some sections were taught using traditional methods of instruction.

Students' scores on a pre-test and post-test were used to measure the effect of the NMIS on students' achievement. Comments collected during 11 focus group sessions with 124 students at Lemoore and Sanger were used to examine students' attitudes toward courses incorporating the system. Interviews with the instructors explored the effect of the system on instructors' workloads. In addition, we observed classes to gather information that would supplement and illuminate the principal sources of data. We also collected other data, such as students' scores on standardized tests, to determine the comparability of the students in both groups of each course (i.e., students using the NMIS, and students being instructed with traditional methods).

FINDINGS

The data indicate that the NMIS has a positive effect on students' academic achievement. In each of the three courses that participated in this study, students in the NMIS group achieved greater percentage gains from the pre-test to the post-test than did students in the group using traditional methods of instruction.

Students reported that multiple representations of the course material help them understand it better than, for example, just hearing an instructor talk about it; immediate feedback during the tests is helpful; and mechanical aids imbedded in the system improve students' productivity. In addition, they commented that, relative to courses using traditional methods of instruction, (1) lectures are better organized, consequently they are easier to follow and there is more time during the class period for discussion and students' questions, (2) course reading materials are more compelling than ordinary textbooks because the system interacts with the students, e.g., it locates material instantly and provides hypertext links to pictures and a glossary, and (3) instructors are more likely to supplement standard course material with, for example, articles from the morning's newspaper, which makes the lessons more relevant and more interesting.

Data collected during interviews with the instructors indicate that the NMIS has a favorable effect on their workload. More specifically, relative to traditional methods of instruction, (1) lessons are supplemented, updated, and corrected more easily with the NMIS, (2) an "enormous" number of hours of clerical work have been eliminated because most of the tests are scored entirely by the system, (3) less preparation is required before class because lecture materials are better organized, (4) less class time is required to deal with routine administrative matters such as collecting and returning students' papers, etc., (5) less class time is needed to prepare students to receive the lesson (i.e., to "settle down," get out their paper, pen, and textbook, and turn to the designated chapter), and (6) less class time is taken to set up and operate audio and visual aid equipment because, with the system, the equipment is activated by clicking "buttons" on the instructor's notes instead of physically connecting plugs, turning switches, operating a bar code scanner, etc. Instructors commented that the NMIS makes the classroom experience more rewarding for instructors because it has a positive effect on students' attitudes and helps the students to stay on track. Instructors said unanimously that they would recommend the NMIS to other NJROTC units because of the benefits it provides for instructors and students.

DISCUSSION

The improvement in students' scores from pre-test to post-test supports the assertion that the NMIS has a positive effect on students' academic achievement. However, interpretation of the test scores is subject to several caveats. On one hand, scores were not identified by individual (to protect students' privacy), and, even though the attrition in the matched groups was comparable during the period of the study, the outcomes may have been affected by disproportionate losses of students who had different levels of academic performance. On the other hand, the scores may understate the effect of the NMIS. Naval Science 1 students had to learn to use the system, and they may have gained proficiency with it only near the end of the study period. Further, material covered during the first ten weeks of the courses may have been learned relatively easily; had the study been of longer duration, the courses would have covered more material and, perhaps, more challenging material, and the differentials between the groups' average scores may have been greater.

Data collected on the students' attitudes about courses using the NMIS suggest that the system did, indeed, foster higher levels of academic achievement. The students' comments lend support to the argument that the factors initially posited (i.e., multiple representations of material, immediate feedback, labor-saving tools) were instrumental to the outcome. In addition, the students' comments suggest that other factors may be relevant and should be examined in a more rigorous study. Specifically, the technology itself and the active interface dialog may be motivators. Further, the discipline that is imposed by the system may cause students to do work that, otherwise, they would avoid.

Instructors reported that the system has a positive effect on their workload in terms of time saved and enhanced interaction with students. Their comments suggest that the NMIS encourages and facilitates the use of instructional methods that are well-regarded by students and instructors. Some of these methods could be replicated, at least in part, by additional work and by the use of other media, e.g., transparencies. However, some instructors appear to be daunted by the logistical problems of using multiple media, particularly in concert, and the outcome is that, without the NMIS, lectures typically include few visual aids, they often are not well-organized, and, from

the students' perspective, they often are dull, hard to understand, and not engaging.

In its present form, the NMIS is used to deliver instruction in, basically, a traditional manner. We believe the NMIS presents an opportunity to introduce pedagogical innovation that encourages and enables students to become more actively involved in their education. We encourage CNET to consider the ways they might promote this type of change.

This study did not investigate the implementation of the system. However, users' comments about their experiences with the system, their recommendations for on-going support, and our observations indicate that proper implementation and on-going support are critical to the system's success.

CONCLUSIONS

We believe the findings suggest opportunities for CNET that go beyond using the NMIS solely as a vehicle to deliver instruction via relatively independent systems located at individual schools. The NMIS enables CNET to maintain a "virtual presence" at NJROTC units. It presents opportunities for pedagogical innovation. It can be used to enhance the interaction of NJROTC units with the school community. Anecdotal evidence suggests that the NMIS can help attract more and better students to the NJROTC program. In addition, NMIS technology enables CNET to publish and distribute course materials electronically, which suggests a potential for marked cost-savings in the administrative and logistical costs associated with traditional textbooks and other materials.

The findings of this exploratory study cannot be generalized to other locations because the sample includes only two schools, which may have unique characteristics; the sample size is too small to provide statistical validity; and students and instructors were not assigned randomly to groups, consequently, there may be an inherent bias that favors one group. Even so, the findings are informative and, we trust, they will be helpful to CNET.

The findings indicate that a more rigorous study would be worthwhile. We recommend identifying the "critical success factors" of the

NMIS. In particular, learning more about the training and technical support needs of NMIS users (both students and instructors) would be a valuable aid to designing effective implementation procedures.

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Chapter One

INTRODUCTION

The Navy Junior Reserve Officers Training Corps (NJROTC) provides a four-year high school program that includes an academic component and a military drill leadership experience. Through NJROTC course work, cadets learn about world politics and geography and their effect on world affairs, naval history and traditions including sea and space science, Navy operations, ships, aircraft, tactics, career and educational planning, and personal health issues (Sundt, 1991). In the main, students in the NJROTC program use textbooks and standardized tests provided by the office of the Chief of Naval Education and Training (CNET). At two high schools, the Naval Science department is authorized to offer courses (such as American Government) that students may take to fulfill regular academic requirements; in those courses, students use the school's standard textbook.

Approximately ten years ago, a computer-based NJROTC multimedia instructional system (NMIS) was developed to enhance the delivery of NJROTC curricula. The NMIS was developed by Captain John Nicholson when he was the Naval Science Instructor at Sanger High School, Sanger, California. The system has undergone extensive and relatively continuous refinement since its inception, and it has been adopted by other high schools. For example, it was implemented in the NJROTC program at Lemoore High School, Lemoore, California, during the fall term of school year 1994–1995. During school year 1995–1996, the system was being used at Lemoore and Sanger to teach Naval Science 1, Naval Science 2, American History, American Government, and Economics, and, at Sanger only, Current Events and World History.

In this study, we examined the effectiveness of the NMIS at Lemoore and Sanger in terms of three broad research questions:

1. Does the system have a positive effect on students' academic achievement?
2. What are the students' attitudes toward courses using the system?
3. What effect, if any, does the system have on instructors' workload?

The data collected in this study indicate that the NMIS has a positive effect. However, a caveat is in order. It would not be appropriate to conclude that similar results will be achieved at other locations. This was an exploratory study (Yin, 1989) that did not subject the assertion to a formal test (e.g., it did not use randomly selected control groups and treatment groups or a sample sufficiently large to provide statistical validity). Even with this caveat, the findings of this study are informative and, we trust, they will be useful to CNET.

A description of the system is provided in Chapter Two of this report. Chapter Three discusses the theoretical foundations of the three research questions. Chapter Four describes the study methodology, including the evaluation design, sample, and data components. Chapter Five presents the findings of the study relative to the three main research topics, i.e., students' achievement, students' attitudes, and instructors' workload. Chapter Six discusses the findings. Chapter Seven presents concluding remarks, which include our opinion that the potential of the NMIS goes beyond its current applications in ways that suggest important implications for CNET and the NJROTC program.

Chapter Two

DESCRIPTION OF THE SYSTEM

The NMIS is designed to organize students' study of course materials. It also is intended to help instructors integrate supplementary material (graphics, video clips, text, etc.) into their lectures and into the students' reading materials. In addition, the system offers instructors features that facilitate assessment and record-keeping.

The NMIS is not intended to replace instructors. Rather, it is used interactively by instructors and students while they are engaged in the exchange of information, i.e., during the instructor's lecture and the discussion period. It provides a guide for students to use when they are taking lecture notes. Students also use it to read the course materials and take notes on those materials. Further, the system is used to administer tests of the students' understanding of the course curriculum.

The NMIS is intended to pattern users' behavior relative to a set of tasks. To appreciate the potential effect of the NMIS, the reader must have a clear understanding of the system's components and its functionality, that is, the manner in which it is used in the classroom. The following information is based on discussions with the developer of the system, on discussions with instructors and students, and on our observations during site visits.

THE PHYSICAL CONFIGURATION

Lemoore and Sanger each have one NMIS classroom. It contains an instructor's workstation, a "home-theater"-size television monitor, and a computer for each student.

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The instructor's workstation includes a computer (i.e., computer unit, monitor, keyboard, and mouse), videocassette player, laser disc player, and a switch that connects the output from either the video or the laser disc player to the television monitor. The instructor's machine has supervisory control over the students' machines, that is, instructors can download/upload material to/from the students' machines, and they can lock the students' keyboards (e.g., to prevent them from using the system during certain class activities).[1]

The NMIS classroom is diagrammed and discussed more fully in Appendix A.

Auxiliary components of the system, which are located in an adjacent room, include one or more computers, a scanner, and a printer. Instructors use the auxiliary computers to develop course materials and prepare administrative reports, correspondence, etc. They use the scanner to digitize tests and supplementary course materials such as newspaper and magazine articles. Students use the auxiliary equipment for independent research and to prepare materials for NJROTC-related activities; for example, the leader of the drill team at one school uses it to prepare instructions for team members.

Software

The NMIS is constructed from off-the-shelf software packages such as Claris Works that enable applications to be modified via user-accessible features (e.g., "routines," "procedures," and "macros"). Expertise with information systems is not required to maintain the system (as might be the case, for example, if its modules had been written in programming code such as "C"). Instructors require relatively modest technical knowledge to develop and/or tailor course material.

[1] An instructor said, "I lock the students' keyboards when I see them not using the system for an assignment—or when they're typing and I'm talking, and they should not be taking notes—for example, during announcements, when I'm giving instructions for a test, etc."

Links to External Information Sources

Course materials, "Instructor's Notes," and the students' files are the main types of information that are stored within the NMIS; they are discussed below. In addition, the system provides links to external sources of information.

The "Magazine Data Base" was complied by Captain Nicholson during his tenure as Naval Science Instructor at Sanger. It consists of a database that contains citations and key words for magazine articles that are relevant to NJROTC courses, plus hardcopies of the magazines. Students use the database and hardcopy collection for research projects.

One computer at Sanger is linked to the Internet. At Lemoore, an Ethernet line is being extended from the main campus communication node to the NJROTC building, so that all of the students' machines will have access to the Internet.

Complementary software also is a source of information. For example, reference materials are available on compact disks at both schools and, at Sanger, students have access to a program that provides information and training exercises for the SAT.

HOW THE NMIS IS USED DURING CLASS

Typically, the NMIS is used each class day (excluding military drill days) by the instructor and all of the students in a class. Instructors can tailor the manner in which the system is used in their courses, and, indeed, we observed variations in its use among the classes we visited. During a typical week, instructors use the system to inform students of the week's schedule and assignments, deliver their lectures on the course material, stimulate discussion, and administer tests. Students use it to read course materials, take notes on the readings and lectures, review for exams, and take tests. The system also may be used for special assignments such as essays and other projects.

Schedule for the Week

At the start of a week, the instructor displays a schedule listing the material to be covered and the assignments for the week. The schedule is displayed on the television screen at the front of the classroom and on each student's monitor. Most students copy it (using "cut and paste" commands) to their personal files for future reference.

Reading the Course Materials and Taking Notes

Usually, after the instructor presents the objectives for the day, he asks students to read a specified portion of the course material. They open the appropriate files on their computers, and course material consisting of text and graphics is displayed on their monitors. Most of the material was prepared by third parties (e.g., textbooks have been digitized and input to NMIS). However, some of the material is prepared by the instructor. For example, one instructor inputs articles from the morning's newspaper (using the system scanner) which, he states, demonstrate the relevance of the course to the "real world."

Some of the text in the course material is underlined (indicating a hypertext link). When the text is "clicked," a pop-up window appears that contains graphics (e.g., pictures, maps, and graphs) or a definition of the underlined word or phrase.

Students' monitors display two vertical windows while they are reading the course material. Course material appears in the left window. Students read it at their own pace. As they read, they write notes in their personal "reading notes" file, which appears in the right window. The software organizes their notes in standard outline format (i.e., I, A, 1, a). Students can color the text in their notes to highlight important items.

While students are reading the course material, the instructor can attend to other tasks, e.g., take attendance, do other administrative work, assist students individually, and walk around the classroom to view the work being done by the class (he also can access students' notes from his computer to review their work in detail).

Listening to the Lecture and Taking Notes

As the instructor lectures, "Instructor's Notes"[2] are displayed on the large television screen at the front of the classroom. The "Notes" are comparable to the transparencies and slides that are used for lectures in classes at graduate schools of business and for presentations in business, military, and other organizations. Instructors use a mouse to control the pacing and the display of material on the television screen. They can display entire "screens" or they can choose to display one section of the screen at a time, rather as a briefer who is using transparencies might slide an opaque sheet of paper down a transparency to reveal the next point to be addressed.

Students call up an abbreviated version of the Instructor's Notes to the left window of their screens, and copy it (using "cut and paste" commands) to their personal "lecture notes" file in the right window. The students' version contains major and minor headings, but not the detailed information under those headings that is displayed on the television monitor. Students are encouraged to annotate their copy during the lecture. In particular, they are encouraged to take notes on "foot stompers," i.e., issues stressed by the instructor "that you are likely to see again" (in an exam). In a student's file, outline text is colored red and blue, and the student's notes are colored black. This convention enables students and instructors to identify quickly a student's annotations.

At the instructor's discretion, the course materials (e.g., the textbook) may be available in the left window. Consequently, students can have simultaneous access to up to three different sources of information: (1) the Instructor's Notes on the television screen at the front of the room, (2) their personal notes in the right window of their screens, and (3) the text and other course materials in the left window.

Video clips from the CNET laser disk are interwoven seamlessly into the instructor's lecture. Instructors install "buttons" in their Notes at places where they want to illustrate their comments with items from the laser disk. During their lecture, they click a button to display an item. The buttons are linked to laser disk bar-codes. This procedure

[2]In some courses, the outline was scanned from the NBOTL *Instructor Guide*.

simplifies the former practice which required instructors to locate the appropriate bar codes during their lecture, and then scan them with a reading device.

Instructors have installed links from NMIS to other software that they use during their lectures. For example, they use map software which displays the Earth in color on the television screen. The software rotates the globe, focuses on a large region (e.g., Europe and the Middle East), narrows the focus to a smaller region (e.g., Italy, Greece and Turkey), further narrows to a country (e.g., Italy); and, finally, narrows to an area within the country (e.g., The Piedmont).

Instructors can walk around the room as they lecture and use a cordless mouse to control the pacing and display of the Instructor's Notes. Among the benefits of this practice: Instructors can observe students' note-taking activity. Of course, instructors also can review the students' lecture notes in detail by accessing the students' files via the instructor's computer (just as they can access and review students' notes on the readings).

Classroom Discussion

During and/or after their lectures, instructors engage students in dialog about the subject matter. Sections of Instructor's Notes and items from the CNET laser disk can be revisited easily by the instructor, when appropriate.

NMIS provides a novel method for reviewing course material and eliciting discussion among the students. At the touch of a mouse button, the instructor displays a question on the television monitor at the front of the room.[7] The system generates a random number between 1 and 28 inclusive, displays it in the corner of the screen, and begins to play the theme music from the television quiz show "Jeopardy." The number designates a computer station. When the music stops, the student who is seated at the designated computer gives his or her answer. Then the instructor clicks his mouse to reveal the correct answer on the television screen.

Some class sessions, particularly those immediately before exams, are used to review course material and lectures. In some classes,

students are able to print a hard copy of their notes on the readings and lectures, and review them outside the classroom.

Assignments, Essays, and Special Projects

"Homework" is something of a misnomer because most of the assignments are done during the class period. (Homework in Naval Science 1, generally, consists of the questions in the text and vocabulary exercises.) However, some students do their "homework" during lunch and after school.

The use of essays and special projects varies by course and by instructor. Students can be asked to write essays using their notes on the course material and/or on the lectures. Their computer screen displays two windows. The student's notes appear in the left window. The essay is written in the right window.

Some instructors call up students' homework to the instructor's computer, copy each student's work to a new file, comment on the work (in the new file) using text and graphics provided by the NMIS editor, and return the annotated homework to the students. This procedure (putting the instructor-annotated homework in a separate file) preserves the unmarked files, thus documenting the students' progress during the course.

Examinations

Examinations are administered using a software package ("LXR Test") that has been integrated transparently into the NMIS. The package prepares tests in various formats, e.g., multiple choice, true/false, matching, completion, numeric, and open-ended. It also allows graphics to be used. For example, one instructor scanned a map, replaced the country names with "A," "B," etc., then asked students to name "Country B."

When students take an exam at their computers, they are informed whether they are correct each time they answer a question (after they "mark" or finalize their answers). If they are incorrect, the correct answer is shown.

During the exam, students are informed of the number of unanswered questions and the amount of time remaining in the test period. At the end of the exam, they are given a summary report of their performance. Each student's answers are available to the instructor's computer, and reports are prepared for him showing grades by student (as raw scores, percentages, or letter grades), class rankings, class performance by question, etc.

Chapter Three

THE RESEARCH QUESTIONS

Learning theory suggests that the NMIS has numerous distinctive features that may enrich students' classroom experience and help them assimilate the curriculum better than traditional methods of instruction. For example, lectures seamlessly incorporate graphical materials from the CNET laser disk and other sources, and reading materials are presented with hypertext links to pictures and a glossary. According to learning theory, multiple representations of material are likely to promote retention on the part of students (Kaput, 1989).

In addition, immediate feedback during exams provides positive reinforcement that, as explained by behavioral theory and extensions to it (cf. Bandura, 1982), plays an important role in the acquisition of new behaviors. Further, the system organizes students' and instructors' activities in ways that may facilitate the delivery, comprehension, and retention of course material.

These considerations lead to the first broad research question:

1. Do students who are enrolled in classes that use the NMIS achieve higher levels of academic performance than do students in classes that are taught with traditional methods of instruction?

The tools embedded within the NMIS may enable students to work more effectively and instructors to work more productively relative to traditional methods of instruction. However, information systems incur costs as well as benefits (Eason, 1984; Noble, 1984), and both the costs and benefits can be distributed disproportionately among

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groups of users (Grudin, 1988). Users' perceptions of their personal costs and benefits are likely to affect their motivation to use a system (Devin, 1994).

Consequently, it is salient to learn whether students are engaged by the system and whether they perceive it, on balance, to improve the learning process for them.

2. What are the students' attitudes about NJROTC courses that use the NMIS relative to courses that are taught in the traditional manner?

Similarly, it is appropriate to ask instructors whether the cost/benefit ratio is equitable for them, and whether "productivity" gains, if any, have positive net outcomes.

3. What is the perceived effect of the system on instructors' workload?

The three research questions are used as devices to explore, organize, and focus the constellation of wide-ranging issues that are encompassed by this study.

Chapter Four

METHODOLOGY

This study compares students in classes using the NMIS with students in classes not using the system. We were unable to randomly assign students to treatment and control groups because of logistical and time constraints. However, before the start of the study, students were assigned to classrooms based on standard school scheduling procedures. Some of the classrooms were equipped with the NMIS while other classrooms were not. This study makes use of these naturally occurring groups.[1]

We examined the use of the NMIS at two high schools, Lemoore and Sanger, during the fall 1995 school term. The principals of the schools notified parents of the study and requested them to inform the principal if they did not want their child to participate in it. We were advised that one parent at Lemoore and no parents at Sanger refused participation for their child.

THE SAMPLE

The sample consists of more than 250 students who were enrolled in three courses: Naval Science I (NS I) at Lemoore, NS I at Sanger, and American Government at Sanger. These courses were selected because some sections of each course were taught using the NMIS.

[1]In this report, terms such as the "NMIS group," "NMIS sections," and "NMIS classes" refer to students who used the system. Similarly, terms such as the "Traditional group," "Traditional sections," and "Traditional classes" refer to students who were taught with traditional methods of instruction.

and other sections were instructed with traditional methods.[2] The sample is summarized in Table 4.1, which shows by course, section (class period), and method of instruction; the number of students who took the pre-test (discussed below) at the beginning of this study.

Table 4.1

Participation in the Study

Class Period	Number of Students NMIS	Traditional	Instructor
Naval Science 1, Lemoore			
2	18		Mr. A
3	19		Mr. A
4	18		Mr. A
7		26	Mr. A
Naval Science 1, Sanger			
2	26		Mr. B
5	22		Mr. B
1		29	Mr. C
2		27	Mr. D
American Government, Sanger			
6	30		Mr. B
4		29	Mr. E
5		35	Mr. E
Total	133	146	

Naval Science 1, Lemoore High School

The Naval Science 1 course at Lemoore had four sections. All of the sections were taught by the same instructor. Three of the sections were scheduled to be given in the NMIS-equipped classroom. However, before the school year started, more students were assigned to the fourth section than the NMIS classroom could accommodate, so

[2]We also believed the data collected from the NS 1 courses would be particularly informative because these students would be experiencing the NMIS for the first time (unlike students in advanced courses who were likely to have used the system previously), and they would draw upon recent experience with the system to discuss the ease of learning to use it and their initial impressions of it.

this section was scheduled to be held in a typical classroom where traditional methods of instruction would be used.

Some of the students dropped the course during the school term (the rate of attrition was comparable in all of the sections). The section being taught with traditional methods became small enough to move to the NMIS classroom. However, this change was deferred until the end of the formal period of the study, that is, until after the post-test was administered.

Naval Science 1, Sanger High School

Sanger's Naval Science 1 course had eight sections. Two sections were taught in the NMIS-equipped classroom. Six sections were conducted in a typical classroom using traditional methods of instruction because they were scheduled during periods when the NMIS-equipped classroom was occupied by other classes. Four sections were selected to participate in this study: the two sections using the NMIS, and two of the sections using traditional methods of instruction. The two NMIS sections were taught by the same instructor. The two Traditional sections were taught by two other instructors.

At the start of the school year, 121 students were officially enrolled in these four NS 1 sections (Table 4.1 shows the number of students who took the pre-test). Approximately 47 percent of the students were in the NMIS group and 53 percent were in the Traditional group. These percentages held relatively constant during the period of the study. We are advised that no students transferred between the sections of the course after the pre-test was administered.

American Government, Sanger High School

The American Government course at Sanger consisted of eleven sections. An NJROTC instructor taught one college prep section using the NMIS. Teachers in the Social Science Department used traditional methods of instruction to teach the other ten sections, of which four were college prep sections and six were "regular"

sections. The same textbook was used in all five college prep sections of the course.

The principal of the high school informed us that students were distributed randomly among the sections of the course—with the following exceptions: (1) college prep students were separated from "regular" students, (2) two of the college prep sections were "remedial," i.e., for students with reading problems, and (3) NJROTC determined who would be admitted to its section of the course.

The Naval Science Instructor informed us that, typically, more students applied for the NJROTC section of the course than it could accommodate. On August 3, 1995, 65 students had applied for the 30 slots in the course, and more students were expected to apply before the school year began. Usually, NJROTC accepted only those students (1) who had been in NJROTC for at least three years and (2) who had "demonstrated leadership," that is, who were suitable to serve as NJROTC cadet officers and leaders.

The NJROTC section of the American Government course and two of the "non-remedial" college prep sections were selected to participate in this study. The instructors agreed to cover the same chapters of the textbook during the period of the study. The three sections had comparable numbers of students; approximately 30 percent of the students were in the NMIS group.

Students did not transfer between the NMIS section and the Traditional sections of the course.

STUDENTS' CHARACTERISTICS

We collected demographic data from the schools' records to examine the comparability of the students in the NMIS and Traditional groups. The data for students in the NS 1 course are summarized in Table 4.2 by method of instruction; they describe the students' grade level, gender, ethnicity, standardized test scores, and participation in the free or reduced-price lunch program.

Naval Science 1, Lemoore High School

As reported in Table 4.2, the average CTBS scores[3] of NS 1 students in the Traditional group at Lemoore were higher than the average scores of the students in the NMIS group by 10, 11, and 8 points, respectively, for reading, language, and math. The differences between the groups are not statistically significant. However, the data indicate that, on average, students in the Traditional group were more proficient in reading, language, and math skills than students in the NMIS group.

Table 4.2

Demographic Data for NS 1 Course by Method of Instruction

	NS 1 Lemoore[a]		NS 1 Sanger[b]	
	NMIS	Traditional	NMIS	Traditional
Scores				
Reading	772	782	745	754
Language	756	767	748	742
Math	779	787	761	757
Grade level				
9th	71%	83%	58%	47%
10th	27%	13%	32%	47%
11th	1%	0	5%	3%
12th	1%	4%	5%	3%
Gender				
Male	44%	42%	65%	59%
Female	56%	58%	35%	41%
Free/reduced lunch	18%	17%	23%	13%
Ethnicity				
Hispanic	15%	4%	65%	53%
All other	85%	96%	35%	47%

[a]Data pertain to the 95 students who were officially enrolled in all sections of the NS 1 course when the post-test was administered.

[b]Data pertain to the 121 students who were officially enrolled at the start of the school year in the four NS 1 sections that participated in this study.

[3]Lemoore scores are from the Spring 1986 Comprehensive Tests of Basic Skills (CTBS), which included "reading" (vocabulary and comprehension), "language" (mechanics and expression), and "math" (computation, and concepts and applications).

The NMIS group had proportionately fewer freshmen and proportionately more sophomores than the Traditional group. The distribution of male and female students was approximately equal in the two groups. The two groups are relatively comparable in terms of the percentage of students participating in the federally funded free or reduced-price lunch program. (We use this measure as a surrogate for the students' socioeconomic status (SES).) The NMIS group had a larger proportion of Hispanic students than the Traditional group.

Naval Science 1, Sanger High School

Table 4.2 shows that, on average, students in the Traditional group scored nine points higher than did students in the NMIS group on the CAT/5 reading module, six points lower than the NMIS group on language, and four points lower on math.[4] The differences are not statistically significant. However, the data indicate that, on average, students in the Traditional group were more proficient in reading skills than were students in the NMIS group.

The NMIS group had proportionally more freshmen and fewer sophomores than did the Traditional group. The NMIS group had a somewhat larger proportion of female students than the Traditional group. In comparison with students in the Traditional group, almost twice as many students in the NMIS group participated in the reduced-price or free lunch program.[5]

More than 50 percent of the students in the four sections were Hispanic. This statistic is representative of the student population at

[4]Sanger scores are from the Fall 1995 California Achievement Tests (CAT/5), which included "reading" (comprehension only), "language" (mechanics and expression), and "math" (computation, and concepts and applications).

[5]Even though the NS 1 groups at Sanger are not comparable in terms of SES (as indicated by participation in the free or reduced-price lunch program), students' comments during the focus groups suggest that economic advantage/disadvantage was not directly relevant to their access to systems technology. In general, Sanger students reported that they gained basic experience with information systems by using computers at their elementary schools and/or junior high schools. They also reported that while they were in grade school, they could borrow laptop computers from the school library and take them home, in the same manner that they borrowed books.

Sanger. However, Table 4.2 shows that approximately 65 percent of the students in the NMIS group were Hispanic (a ratio of 1.8 to students in all other ethnic groups), whereas 53 percent of the students in the Traditional group were Hispanic (a ratio of 1.1).

The distribution of students by ethnicity is relevant because, on average, Hispanic students' CAT/5 scores were substantially lower than the scores of students in all other ethnic groups. Relative to other students' scores, the scores of Hispanic students were, on average, 35 points lower in reading, 36 points lower in language, and 35 points lower in math. These differences are statistically significant.

The data suggest that the NMIS group, on average, had a lower CAT/5 reading score than the Traditional group (745 versus 754) because the NMIS group had a larger proportion of Hispanic students (65 percent versus 53 percent), and the Hispanic students' scores, on average, are lower than the average scores of students in other ethnic groups.

American Government, Sanger High School

All of the students in the three participating sections of the American Government course were seniors. As reported in Table 4.3, relative to the Traditional group, the NMIS group had proportionately more female than male students and proportionately more Hispanic students than students of other ethnicities.[6]

DATA COLLECTION

Evaluation data consist of scores on a pre-test and post-test, students' comments during focus groups with users and non-users of the system, interviews with instructors, and observations of classes.

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[6]Demographic data were collected from the schools' records after the post-tests were administered. On reviewing the post-test scores in the American Government course, we determined that our understanding of them would not be illuminated either by the students' scores on the CAT exam or by their participation in the free or reduced-price lunch program, and we elected not to spend the resources that would have been required to collect that data.

Table 4.3

Demographic Data for the American Government Course by Group

	NMIS	Traditional
Grade Level		
12th	100%	100%
Gender		
Male	43%	50%
Female	57%	50%
Ethnicity		
Hispanic	37%	25%
All other	63%	75%

NOTE: Data pertain to the 94 students who took the pre-test.

The Pre-Test and Post-Test

Students' academic achievement, i.e., the focus of the first research question, was measured by their scores on a test covering material that the instructors planned to include in the course during the period of this study. The NS 1 test consisted of questions taken from CNET's test battery. The American Government test consisted of questions selected from a test battery prepared by the publisher of the textbook that was used by the three sections of the American Government course that participated in this study.

The pre-test was administered to the students at the start of the term to measure their knowledge of the subject matter before instruction began. The post-test was given near the end of the term to measure their knowledge of the subject matter after, approximately, 10 weeks of instruction. The tests were prepared, administered, and graded by RAND personnel.

Focus Groups

Students' attitudes about NJROTC courses using the system, i.e., the central issue of the second research question, were addressed during focus group sessions. Eleven focus groups, with 124 students in total, were conducted at Lemoore and Sanger.

At Lemoore, we met with students in all of the NJROTC courses—including courses that were not participating in the study. Students in the non-participating courses were using the NMIS currently, and most of them had used it during the previous academic year. We met with them to collect data regarding the perceptions of relatively well-experienced users of the system.

Students in the Traditional group at Lemoore had begun to use the NMIS shortly after the post-test was administered. When we met with them, they had been using the NMIS for approximately four weeks. We were particularly interested in their initial reaction to the system and their perceptions of it relative to traditional methods of instruction. We met again with this group approximately three months later to determine whether their initial views of the system had changed as they gained familiarity with it.

At Sanger, we met with NJROTC students in (1) all three of the participating groups that used the NMIS, (2) one of the participating sections that was using traditional methods of instruction, and (3) a group composed of students in advanced NJROTC courses who had used the NMIS previously during one or more years.

Approximately half of the students in each class section were randomly chosen to attend the focus groups. Each focus group consisted of approximately 12 students. The participants adjourned to a room outside the classroom to discuss the system with RAND personnel. Instructors were not present during the focus group sessions.

In the main, topics discussed with users included: differences between classes using the NMIS and classes using traditional methods of instruction; experience using the system, including the process of learning to use it; effectiveness of specific components of the system; uses of the system outside of NJROTC class; and recommendations for improving the NMIS. We asked students who had seen the system, but who had not used it in class, about their perceptions of classes taught using the NMIS versus those taught with traditional methods of instruction.

Interviews of Instructors

The constellation of issues relating to the third research question was discussed during interviews with the instructors. All of the instructors who used the system were interviewed. Their comments covered (1) their views regarding the effect of the system on their workload, pedagogy, and their interaction with their students; (2) their estimates of the amount of training instructors need to use the system; and (3) their overall assessments of the system, i.e., whether they would recommend it to other NJROTC units.

Observation of Classes

We visited classes to collect information that would supplement and illuminate the data that were collected during the tests, focus groups, and interviews. We observed all of the class sections at Lemoore, including sections of advanced NJROTC courses where most of the students had used the system in one or more courses previously. We included advanced courses to examine whether students' interaction with the system changed as they gained experience with it, and whether there were differences in the use of the system among the instructors. Similarly, we observed approximately half of the NJROTC class sections at Sanger and one of the Social Science Department courses that was participating in this study.

Chapter Five

FINDINGS

The findings of this study are organized by the three research questions regarding (1) students' academic achievement, (2) students' views regarding the system, and (3) instructors' perceptions of the efficacy of the system relative to their workload. This chapter also includes data about the integration of the NMIS into the larger school culture.

STUDENTS' ACADEMIC ACHIEVEMENT

As reported in Table 5.1, the average scores of students using the NMIS increased more from pre-test to post-test than did the average scores of students who were taught with traditional methods of instruction. We focus on the increase in scores because two of the matched groups (NS 1 at Lemoore and American Government at

Table 5.1

Average Scores on Pre-Test and Post-Test

	Method	Pre-Test	Post-Test	Change	
NS 1, Lemoore	NMIS	31.7	42.1	+10.4	32.8%
	Traditional	37.9	43.0	+5.1	13.5%
NS 1, Sanger	NMIS	33.7	41.5	+7.8	23.1%
	Traditional	33.4	38.7	+5.3	15.9%
American Government, Sanger	NMIS	17.2	22.3	+5.1	29.7%
	Traditional	19.2	17.8	−1.4	−7.3%

Sanger) did not have comparable familiarity with the course material at the start of the study.

Brief descriptions of the data follow. More detailed descriptions can be found in the appendices. Note that the same tests were used in the NS 1 courses at Sanger and Lemoore, but the scores should not be compared directly because the two courses covered somewhat different material.

Naval Science 1, Lemoore High School

The NMIS group in NS 1 at Lemoore scored 6.2 points less on the pre-test than did the Traditional group, and the difference is highly significant ($p = 0.0002$). However, the difference in the groups' post-test scores is not statistically significant ($p = 0.6390$). In other words, the data indicate there is a zero probability that students in the two groups had the same knowledge of the course material when the study began, but their knowledge of the material was not significantly different when the study ended.

The average score of the NMIS group increased 32.8 percent (i.e., up 10.4 points, from 31.7 to 42.1) whereas the average score of the Traditional group increased 13.5 percent (i.e., up 5.1 points, from 37.9 to 43.0). The 6.2 point "advantage" of the Traditional group on the pre-test (37.9 versus 31.7) was narrowed to 0.9 point on the post-test (43.0 versus 42.1).

Naval Science 1, Sanger High School

At Sanger, the 0.3 point difference in the NS 1 groups' scores on the pre-test is not statistically significant ($p = 0.8672$), but the 2.8 point difference on the post-test in favor of the NMIS group is statistically significant below the 10 percent level ($p = 0.0679$). In other words, the groups had a comparable understanding of the course material at the beginning of the study; however, there is a less than 10 percent probability that the NMIS group's higher average at the end of the study is a random event.

American Government, Sanger High School

In the American Government course, the NMIS students had, on average, a lower pre-test score than students in the Traditional group, and the difference is statistically significant below the 10 percent level ($p = 0.0796$). The NMIS group's average score increased 29.7 percent (5.1 points) from pre-test to post-test whereas the Traditional group's average score decreased 7.3 percent (−1.4 points). The difference in the groups' post-test scores is statistically significant ($p = 0.0015$). The increase in the NMIS students' average score is consistent with the gains achieved by NMIS groups taking NS 1, but the decrease in the Traditional group's score is surprising.[1] We return to these outcomes in the next chapter of this report.

NMIS Effect Relative to Ethnicity

At Sanger, analysis of the change in NS 1 test scores by ethnicity highlights a potentially important contribution of the NMIS. Hispanic students in both groups had significantly lower pre-test scores than did students of other ethnicities. However, Hispanic students in the NMIS group achieved a 23.4 percent gain from pre-test to post-test (slightly ahead of the 22.1 percent gain for NMIS students of all other ethnic groups). In contrast, Hispanic students in the Traditional group achieved a gain of 15.5 percent (comparable to students of other ethnicities who were in the Traditional group).

It is not meaningful to analyze the scores at Lemoore by ethnicity because there are insufficient numbers of students in each category to provide statistical validity.

STUDENTS' ATTITUDES

Overall, the 124 students who participated in the focus group sessions at Lemoore and Sanger were strongly positive and overwhelmingly enthusiastic about the NMIS. There was a high level of consistency among their comments. In sum, they reported that they prefer

[1] The decline of the Traditional group's average score from the pre-test to the post-test is an anomaly. We suggest that readers should exercise care when using data pertaining to the American Government course.

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NJROTC courses using the system to courses using traditional methods of instruction. They said the NMIS makes their course work "more understandable," "easier," "enjoyable," and "fun." In each group that had used the system, the overwhelming majority of the students said they would recommend classes using it to their friends.

Four central themes stand out in the students' comments. The first theme relates to the structure that is imposed by the system on the instructor's lecture and the students' work. The second major theme relates to attractiveness of the NMIS technology. The third theme concerns the ease with which the system is learned and used. The fourth theme concerns the manner in which students' perceptions of the system change as they gain experience with it.

The quotes below are representative of comments made by the majority of the students. To respect the privacy of the students and their instructors, comments are not identified by school or by course.

The System Organizes Work Efficiently

Students said the NMIS organizes their instructors, the class periods, and their own work. They described the structuring that is imposed by the NMIS as a positive attribute.

They said they like receiving the class schedule at the start of the week. Most said they copy it to their notes, so they can refer to it as the week progresses.

Relative to classes taught with traditional methods, students said the lectures in NMIS classes are easier to follow and understand because the system organizes instructors' presentations in a manner that highlights the main issues.[2]

> In other classes you don't know what the instructor is saying that's important.

Students reported that there is more time in NMIS classes for discussion—which they said is particularly helpful—and they attributed

[2] "Last year [in a NJROTC course not using the NMIS] sometimes the pictures on the laser disc didn't make sense. Now, we know what the pictures mean."

this advantage to the system. They said the NMIS requires instructors to come to class with their presentation already prepared, and it enables instructors to deliver the lesson much faster than traditional methods (e.g., time is not taken to write information on a blackboard, to turn pages in a book, to recall the next point to be addressed).

Students said that the outline shell provided by the NMIS serves to focus the notes they write on lectures and course materials. This focus, they said, helps them when they review for tests and when they write essays from their notes. However, one senior commented:

> I don't know if it really prepares you for college. Maybe there's too much guidance.

but another student replied:

> Here [in an NMIS class], I think I learn the subject better, and I learn better how to outline and [identify key points].

We asked students how many notes they take, and the responses ranged from "a lot" to "barely any." Our observations of the NMIS classes and our review of the students' note files indicated that students using the system, on average, take at least a typewritten page of notes during each lecture and on each reading assignment. The amount of notes varies by course and instructor, as well as by student. We observed far fewer notes being taken, on average, in classes using traditional methods of instruction.[3]

Students also commented that the NMIS organizes their work physically. With the NMIS, the material is "right there," readily available for review.[4] In addition, students said they like the system because it provides all the materials they need; in contrast, in other classes, students often forget to bring textbooks, paper, pens, homework, etc.

> You don't need a lot of supplies for this class. You just need fingers.

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[3]A student commented, "In some [non-NMIS] classes, some kids just listen and learn without taking notes. It's not the same here."

[4]"You see kids [in school] with binders with things falling all over the place. Here things are organized. I can find things when I need them."

The Technology Is Compelling

The second major theme of the focus groups relates to the attractiveness of the NMIS technology.

> Studying gets old quick. With the computer, you have more ways to learn.

More specifically, students commented about the appeal of the system in terms of the course readings, lectures, students' notes, and exams.

> It's easier to memorize off a TV than a piece of paper—it's just easier. You can look at a piece of paper over and over and not remember it. It's like a video game—you remember.

Students reported they find course material more engaging when it is presented via the system rather than via a textbook. They perceive that, relative to books, (1) it is easier to scan the material, (2) it is easier to locate information, particularly when reviewing for a test, and (3) hypertext links provide faster access to definitions.[5] Students' descriptions of the hypertext links suggest the interplay of the technology with the mechanics of reading.

> A picture makes you want to read the paragraph—want to see what's behind the picture.

> Sure, I look up the definitions on the system if I don't know them. It's easy. But, I don't look up words I don't know in textbooks. That takes too much time. It's too hard.

Students also said they find the questions at the end of the units in the NS 1 text are helpful, and they like being able to copy the questions into their notes with just a few keystrokes.

Students reported that instructors' lectures are more interesting and more enjoyable in NMIS classes than lectures in traditional courses

[5]Most students reported that they take advantage of the hypertext links to pictures and other graphics, but they use the links to the glossary less frequently because they understand some of the words, and do not need to refer to the definition.

because NMIS lectures use graphical materials more effectively. More specifically, lectures in NMIS classes integrate a variety of material, e.g., pictures, other graphics, and articles from the morning's newspaper.

> You are getting the same things in different ways. It makes it easier to understand and remember them.

However, one student commented:

> There are lots of still pictures. Some are dull. If he's talking about a captain, he just shows a picture of a captain just standing there.

The Instructor's Notes featured prominently in the students' comments.

> It's easier than the instructor writing on a chalk board—you can scroll back if you want [if you miss something]—and you can copy it [with a couple of keystrokes].

> I'd miss a point [in other classes, and] I'd let it go. Here I have his notes.

Students' comments indicate that the NMIS media offer new opportunities to present material. For example, they cited software that displays a rotating Earth, locks on an area, and zeros into a locality (see the subsection "Listening to the Lecture and Taking Notes," Chapter Two).

We asked students whether traditional visual aids (e.g., transparencies, films, etc.) are used effectively in non-NMIS courses. Students told us that, typically, visual aids are not well-integrated into lectures in non-NMIS classes, if, indeed, they are used at all.

> [Other classes] are really boring. The instructors just stand up there lecturing.

As noted above, students commented favorably that the system provides more class time for discussion. They also said the system is used actively to facilitate discussion and review. On one occasion, we observed an instructor pause during his lecture to ask questions

about related material, which the class had covered previously. One student was unable to reply to a question. The instructor said that all of the students should know the answer to this question, and he directed the student who could not respond to call up his notes on the computer and find the answer. Most of the other students, perhaps anticipating that the question might be directed to them, reviewed their own notes while their classmate was thus engaged.

Students also said they enjoy using the "Jeopardy" game as a review device (see the subsection "Classroom Discussion," Chapter Two). During our visits to the classes, we observed the class applauding and whistling if a student's answer was correct. Otherwise, a barrage of good-natured catcalls and banter followed. The game led readily to discussion when it was appropriate to reinforce, amplify, or correct a student's answer.

By far the majority of the students in the focus groups reported that they prefer using the NMIS to take notes on the reading materials and lectures rather than writing notes by hand. They said typing is faster and easier than writing by hand and, many students stressed, they often are not able to read their handwriting when they review their notes. They explained that students are under pressure to write rapidly during non-NMIS lectures, and handwritten notes often are difficult to read because they are terse and messy, and the penmanship is careless.

In addition, students said, with the NMIS they can easily use colors to highlight key concepts.

> It's like memory cues. You can't find them in a regular classroom .... When I reviewed, I saw what was important—my cues helped. I can't do that with hard copy notes. You have to have a lot of pens. Besides, I'm too sloppy.

Students reported that they prefer to take tests on the computer rather than use paper and pencil, in the main, because the system provides immediate feedback.[6] Students noted:

[6]An instructor commented, "There's instant gratification for the students. Students like to know how they did. I've found if you give them the results of a test a week later, they've lost interest."

> In other courses, you have to wait a week to find out how you did. And by then you've forgotten what the test was all about.

Students Find the NMIS Easy to Learn and Use

Students in the NMIS groups reported that they were able to use the system without difficulty, and the one-week orientation to the NMIS was sufficient time to learn how to use it. To use the system, students must be able to perform several basic tasks, which are summarized in Appendix E; these tasks were identified by Captain Nicholson, the developer of the system.

Most of the students reported that they had taken or were taking the school's keyboarding course and were comfortable typing. Those who were not touch-typists said that the system was "more fun" once they learned to type, but that "People go at their own pace. There's no real problem if they can't type too well."[7]

During the focus group sessions, we noted that most of the students reported that they had considerable prior experience with computers. In the main, the students were introduced to computers at school, but many of them also gained experience with computer systems at home. Only a few students reported that the NMIS or the school's keyboarding course was their first exposure to computers. Lemoore students said they began using computers at an average age of approximately 10.5 years. At Sanger, the average age was approximately 11 years. Some of the students reported they had begun using computers in the early years of grade school, and at least two of them had first used a computer while they were in kindergarten. Playing games constituted much of the students' early experience with computers. However, some students reported using computers for math exercises, to write essays, etc.

[7]Instructors reported that most students were able to use the system without difficulty. "I haven't seen any student have problems with the system. When we start, about one-third of the class can't keep up, but that third improves, and they are able to keep up within about six weeks."

Students' Perceptions of the System Evolve as They Gain Experience with It

We talked with students who had never used the NMIS in class, but who were somewhat familiar with the system through discussions with other students. In addition, some of them had used the NMIS computers to type assignments for other courses. Their comments expressed polar views of information technology, e.g., some lauded the opportunity to learn new skills that they perceived as being required in the workplace and in society, but others were wary of system-imposed isolation (i.e., working with a machine instead of people), and were concerned about their technological self-efficacy. It appears these students were evaluating the NMIS based on their experience with other computer systems and/or with their projections of what working with the NMIS entails.

> I hate my computer class [the school's keyboarding course]. You sit behind a computer for a long time [the school has 95 minute periods]. Two back-to-back computer classes would be hard to take.[8]

> When you write [by hand], you have time to think.

We also talked with a group of students who had started using the NMIS late in the school term. We call them the "new users." We conducted two focus group sessions with these students. The first session was held approximately one month after they started using the system, and the second was convened three months later.

During the first session, we were particularly interested to hear new users' perceptions of the system contemporaneous with their initial exposure to it. Over half of them said they liked using the system, and their comments were similar to the comments made by students who had used the NMIS for at least one school term. Most of the new users said they would recommend a class using the system to their friends; however, one student commented:

[8]Typically, when we asked groups of experienced NMIS users if they would like a day of class when they did not use the computer, the students answered loudly, "NO!"

> I wouldn't if they don't have good attention skills, if they hate computers, don't have experience with them, and don't like to try new things.

The group reported that it had used the system to take two tests. Approximately one-third of the students liked using the computer, one-third preferred paper and pencil tests, and one-third said they did not care which medium was used. All of the students, except one, said they liked getting the grade right away. That one student said:

> I get frustrated when I get one wrong. I'd rather not know.

Approximately half of the new users made neutral or negative comments comparable to those we had heard from the non-users. Three of the students had a very strong preference for textbooks and for writing notes by hand, in part, they said, because they lacked keyboard skills and in part because they preferred to use hard copy materials outside the normal class hours.

> Typing doesn't go as fast for me as handwriting. When he lectures us, I don't hear anything he's saying. I read in the book later because I'm too busy typing.

We found that some of the new users were not yet familiar with all of the system options available to them (e.g., finding out how much time was left to complete a test, or how to use the hypertext links).

During the second focus group session with the new users, we explored whether and how their impressions changed as they gained experience with the system. We found continued support for the system among the students who favored it initially. We found there was more support for the system among the students who had been neutral or negative. Approximately two-thirds of the students reported they felt better about using the system, one-third said they felt about the same, and no one reported feeling worse about using it.

Only one student continued to strongly prefer textbooks and traditional methods of instruction to the system.

Students' Recommendations

In general, students reported that they like the system as it is.

> There's nothing we really dislike.

However, their comments identified three aspects that merit attention: hard copy output, file protection, and automatic file-saves.

Some students said they printed hard copy of their work on occasion. However, most of the students reported that they cannot print files, but would like to be able to output their notes, etc., in hardcopy, and read them outside of the class. A few students commented they would like to copy their files to a disk, and then read their notes, etc., on their computer at home. The policy regarding printing appears to be set by the instructors. One instructor commented, "There's a problem letting the students make hardcopy notes, mainly, the big demand for paper." The instructor also was concerned about system security. He noted that, "We could transfer files to students' floppy disk, but I worry that if they brought in a disk, they might download something from it that would have a virus."

Several students reported they had lost files because someone deleted them. This may have been accidental. However, in some courses, students were entering other students' files without permission, and leaving notes.

About one-third of the students in one group had lost files due to server-related problems. The problems appear to have been resolved, but, understandably, the crashes were well-remembered.

Other comments made during the student focus groups suggested enhancements such as including more pictures, particularly color pictures, adding more movies, playing "Jeopardy" more often, learning more about the system (e.g., "shortcuts to use as we gain experience"), getting a more up-to-date text, and "hook it up to the Internet."

INSTRUCTORS' WORKLOAD

Experienced instructors spoke, in a sense, with one voice. Relative to traditional methods of instruction, they find with the NMIS that

lessons are easier to prepare and modify, tests are scored more quickly, and their interaction with students is more satisfying. The comments below are representative of their responses.

Class Preparation Takes Less Time with the System

Once the initial course material has been input into the system, instructors find that their lectures can be modified, updated, and supplemented more easily than with traditional methods of instruction.

> I take the basic lesson guide and tailor it to my particular needs. I add buttons to my Notes where I need them for the laser and VHS. Once it's all there, it's all there. I use each part of the Instructor's Notes just once during a year—but I used it last year, I used it this year, and I'll use it next year. I may update it, and if there's a mistake, I'll correct it. But that doesn't take much effort. It is much easier to modify than written materials. It's simple to cut and paste, reorganize, add a picture, etc. There are so many advantages like that to using a computer. The traditional methods of instruction are very time-consuming.

Reviewing Students' Work Is Easier

Instructors reported major savings of time by using the NMIS to prepare, administer, and grade tests. An added benefit of using the system is being able to determine easily and immediately "who's doing what in class, who needs help."

Instructors also commented that students' work is neat when it is done using the system. Neatness is not a trivial issue, and it affects all types of the students' work (e.g., homework and essays). Instructors reported that it can take several weeks to become accustomed to some students' handwriting. Even then, handwritten materials often are difficult to read.[9] With the NMIS,

> Their typing is clear. All this saves time. I have more time at home. I have more time to assign and correct essays—also, "Mark Up" [the

[9]Similarly, students commented that they like to have their work annotated via the computer because it is difficult for them to read some instructors' handwriting.

> software program used by instructors to annotate the students' work] is much faster than pen and pencil.

As the preceding quote indicates, some instructors prefer to grade students' work at home where, they report, there are fewer distractions and they can work more productively and more comfortably than in the school setting. With the NMIS, they are able to load students' work onto their laptop computer or a diskette, use their computer at home to annotate the students' work, then, back at school, download the corrected material to the students' computers. This process saves time outside the classroom as well as in it, as discussed below.

The NMIS Facilitates Classroom Management

Instructors reported that the NMIS simplifies many routine class management tasks. For example, the system enables instructors to collect and return students' work literally instantaneously without the loss of student attention.[10]

Instructors said the system organizes the students, and enables instructors to pace the class more effectively than do traditional methods.

> As soon as you say, "Let's start," you get going. No time is taken to get pencils and books. There's no time spent with excuses like, "I didn't bring my homework." You can start class at the click of a button. You can control the pace of the class very easily.

The system provides efficient media to deliver instruction, which saves time during class. We asked instructors if it would be equally time-saving to, for example, write/draw on transparencies before class. They responded that it is easier to create materials in the NMIS than on transparencies; moreover, it can be a logistical challenge to integrate traditional media, e.g., to go from the blackboard to the transparency projector to the audio-visual device—particularly if they want to combine a series of brief segments such as a key word

[10]An instructor noted, "Kids lose their attention when you have to take a break to collect homework or hand out graded papers or set up equipment."

written on the blackboard, followed by one picture displayed from the laser disc player, followed by text projected from a transparency.

The NMIS, instructors reported, enables them to manage the class more effectively. First, the system is less distracting to use than traditional instructional media, so instructors can be more responsive to the class and maintain more eye contact with the students. Second, it enables instructors, particularly when they are using a cordless mouse (see the subsection "Listening to the Lecture and Taking Notes," Chapter Two), to walk around the classroom and observe and assist individual students while they are working.[11] Third, instructors reported that the system keeps students organized and on-track which saves class time and makes the class easier and more satisfying to teach.

> When they're working with computers, they aren't bored as they are in the other classes. It's a lot easier to keep them going.

> With the system, the students must take notes all the time. Manually, they stop.

> The system forces the kids to do the work. They can't come in with answers they copied from others just before the class. That happened before! It forces them to do it themselves.

Instructors also reported that the system is more effective than traditional methods when they are counseling students and parents. A student's work is easy to locate, display, and compare with other students' work—and, if needed, a copy can be mailed to the parents for their review.

The System Helps Instructors Enhance the Curriculum

Instructors' comments suggest that, at least in part, the time saved by the system is reinvested in the curriculum. Instructors report they add content to their course because the lectures move more quickly than when traditional methods are used. They download supple-

[11] "Before, I was stuck at the front of the room fiddling with paperwork or playing with the VCR or the OH projector."

mental materials from the Internet, and they can easily "include material from magazines and the morning's newspaper."

> It takes me seven minutes to scan, add comments, and load it onto the students' computers. It is hard for teachers in other [non-NMIS] courses to do all that is required—you know, cut and paste an article to 8.5 by 11 inch paper, type or print notes in the margins, take the sheet(s) to the school's copier [in the main building], wait until the copier is available, make thirty copies, then return to the classroom, and then distribute the material in class.

Homework and Special Projects

Homework assignments are minimal and, typically, utilize texts or other material independent of the NMIS; "homework is almost always a matter of reading something at home, coming in and writing notes about it on the system during class."

Instructors also have students write essays using their notes on the course materials and/or the instructor's lectures. Instructors commented that students quickly learn the benefit of taking good notes.

Some instructors assign special projects (either group exercises or individual exercises), and they may load resource data for these assignments into NMIS. For example, one instructor asked students to write an article about President Lincoln's assassination as if they were a reporter for an English newspaper. The article had to be in newspaper format, and it had to include a graphic. For this assignment, the instructor loaded information and graphics into NMIS. Some students added supplemental materials from other sources (which they entered into NMIS using the NJROTC scanner). In another instance, an instructor loaded recent articles about the proposed flat tax, asked students to read the material, discuss it, and then write letters expressing their views to the U.S. Senators from California.

Learning to Use the NMIS

Instructors divide the process of learning to use the system into two phases. The first phase consists of learning how to deliver course materials that are loaded into the system, generate some additional

material, and administer tests via the system. They estimated that this set of skills takes approximately two weeks to acquire.

> In one week, you could teach a relative newbie to be self-sufficient in terms of presenting and doing some creation of class materials. In two weeks, a new instructor would be comfortable presenting information given to him, using buttons, coordinating the laser disk with the VCR.

The second phase consists of learning to develop a course from scratch, i.e., to load text, create Instructor's Notes and exams, and similar tasks. Typically, that phase was estimated to take an additional two weeks.

However, a new instructor said he was just becoming effective with the system after approximately 12 weeks of teaching. He noted that he had to become familiar with computers, the course material, and the multi-media approach.

> I couldn't have [used HyperCard] to set up the Instructor's Notes and I couldn't have set the buttons when I started. There was no time to learn in the few weeks from when I got here until I started teaching. I had to come up to speed with computers—and with the course materials. Anyone can teach class [after the NJROTC orientation program]. Here I had to learn to use multimedia to do it. I learned with OJT [on-job training]. I'm only now becoming effective.

Would Instructors Recommend the NMIS to Other NJROTC Units?

Instructors stated unanimously that they would recommend installing the NMIS at other NJROTC units. They cited advantages it provides to students and instructors, mainly in terms of the delivery of instruction, motivation and learning, familiarizing students with information systems technology, the potential to innovate in the classroom, and the ability to attract more and better students to the NJROTC program.

Instructors commented that technical support should be provided to new installations—both initially when instructors are learning to use

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it and subsequently as they explore the system's advanced features and embed innovations in their course curriculum. This latter type of support appears to be substantive as well as technical.

> About 50% of our questions . . . concern extensions to the system, "Can we do this . . .?" The other 50% concern . . .the use of technology in education, that is, sharing professional opinions about the use of the system . . . and integrating new software into the system.

EFFECT OF THE NMIS ON SCHOOL CULTURE

The Assistant Superintendent of the Lemoore School District was asked, "Does the NJROTC system [the NMIS] add something that is not present at Lemoore High School?" His reply was an emphatic, "Yes!" He noted that even though the school has integrated information systems technology into its courses to a relatively advanced degree, the NJROTC unit is an exemplar. It is perceived as being on the forefront of change because of its ability to apply an important technology. Similarly, students at both schools commented that other "computer labs" in their school have generic software (such as word processors), but the NJROTC system is distinctive and beneficial because it addresses specific course curriculum.

James Paige, an Apple Computer, Inc., district manager, wrote[12] the following about Lemoore (his comments apply equally to Sanger):

> As you might imagine, in Northern California we see virtually hundreds of schools each year set up similar labs that target all facets of elementary and secondary education. The lab at Lemoore is successful from our viewpoint for the following reasons:
>
> 1. Often, schools . . . utilize the computer as an (expensive) electric typewriter or as a "drill" device. [At Lemoore, students are taught to] utilize the computer as a tool to address many aspects of learning and communicating. Today's students are motivated by this approach and as a result put forth extra efforts in their work.

[12]Personal correspondence dated November 6, 1995

> 2. [The system is integrated into the curriculum.] Rather than make the computer the center of focus, the areas of learning continue to be the major focal point with the Macintosh computers used to augment the learning process.

The NJROTC units at Lemoore and Sanger have operated, as it were, a type of outreach program to other departments of the school. For example, NJROTC personnel at Lemoore gave school personnel a demonstration of the testing software incorporated into the NMIS. As a result, the school obtained a site license for the software, and the faculty are looking to NJROTC personnel for guidance in using it. Sanger NJROTC incorporated the "Personal Trainer for the SAT" into its program, and has invited classes from the English and Mathematics departments to use it.[13]

The maintenance of the equipment is a hallmark of the NMIS installations at both schools, and it is apparent to students[14] and visitors alike.[15] A student commented,

> When you come in here, it's like nothing you've seen on campus before. It's, "oh my gosh!"

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[13]An NJROTC instructor commented, "I want them to have options. I want them to have lots of choices. That's why I have the SAT preparation software. I couldn't have done this without the NMIS equipment. You can't get them interested in a SAT prep guide from a bookstore. They wouldn't do the prep without a computer. They would take it cold."

[14]A student said, "We have faster, more advanced machines in NJROTC [than the rest of the school], and they're maintained better."

[15]James Page of Apple Computer, Inc., wrote, "The lab is maintained in a clean, orderly fashion, and the students are taught to value this resource . . . . By visiting the lab at Lemoore and contrasting it with other labs, one can see this aspect of how the lab is managed. My own personal reaction, when visiting the lab, was to treat the equipment carefully, and with respect . . . . When the time spent in the lab is made part of the overall discipline and respect that is part of the JROTC program, then I believe that there can be no question but that it will be far more successful than other labs where the equipment is not treated with as much respect and in such a professional manner."

Attract More and Better Students

The Naval Science Instructors at Lemoore and Sanger stated that, in their opinion, the NMIS is a principal factor that enables the NJROTC program to attract students.

> The system brings students to the program—and we need numbers—and it brings better-quality students.

> In most programs, there's a pyramid by year, with fewer seniors at the top because they need to satisfy academic requirements for graduation. Traditional NJROTC programs have a tough time getting seniors to take the course as an elective. Last year, we had 55 seniors, and this year we'll have the same or even more.

> The NJROTC program at [our school] draws top students as well as non-college bound students.

Anecdotal evidence appears to support these claims. As reported above (Chapter Four), 65 seniors had applied by early August for the 30 slots in the NJROTC section of the American Government course at Sanger, and more applications were expected to be received before the school year began. A student reported that students want to enroll in the NJROTC section of the course because it covers more material, it is more enjoyable than the sections taught in the traditional manner, and students in it gain computer skills that they believe will give them an advantage in their endeavors after they graduate.

We met NJROTC cadets at Sanger who included student body officers, the just-elected student body president, and a member of the school's Academic Decathlon team. We were advised that a majority of one school's valedictorians and salutatorians in recent years have been NJROTC cadets.

"Extracurricular" Uses of the NMIS

Students use the NMIS outside of NJROTC class time for both academic and extra-curricular purposes. About one-fourth of the students in the focus groups reported that they use the NMIS during "first period" (or "home room" or "study hall"), during lunch, or after

school. Upperclassmen more than freshman said they used the system outside of normal class hours.

They said they use the system to catch up when they miss an NJROTC class, to review material that was covered in class which they did not understand, and to complete assignments. Over half of the students reported they have used the system for academic work in non-NJROTC courses. For example, several students said they had used the Magazine Data Base (see the subsection "Links to External Information Sources," Chapter Two) for non-NJROTC courses such as biology and English.

In addition, NMIS equipment is used regularly for NJROTC activities such as the following:

- The cadet leader of the Drill Team communicates with team members by putting announcements, drill instructions, etc., on the system; team members retrieve the information during their classes, before or after school, etc.
- Cadets use the auxiliary computer to plan the Military Awards Dinner.
- The cadet commanders of the Color Guard and Drill Team record dates of performances, participation by team members, ribbons earned, and date awarded.
- The Rifle Team uses a spreadsheet to keep scores and record the points that are used to determine who gets a varsity letter.
- The auxiliary computer is used for Navy JROTC finances, to complete Navy reports (using templates, so that the information is printed in the correct position on Navy forms), NJROTC inventory (equipment, uniforms, etc.), and administrative correspondence.
- A template in the word processing program that is loaded on the auxiliary computer is used to enter names, dates, and other data on preprinted award certificates; an instructor commented, "It's faster than typing them, and they look a lot better off the laser printer [than a typewriter] because we can use better fonts."

Chapter Six

DISCUSSION

In this chapter, we posit alternative models to explain students' achievement on the tests that were administered by RAND. We observe that the NMIS appears to encourage and structure users' behaviors in ways that are likely to lead to positive outcomes, and this aspect of the system presents opportunities for pedagogical innovation. Finally, we note that students' and instructors' comments suggest that implementation issues are likely to be critical to the success of the system at other NJROTC locations.

STUDENTS' ACHIEVEMENT ON THE RAND TESTS

In all three of the courses that participated in this study, the average scores of the students in the NMIS groups increased more from pre-test to post-test than did scores of students in the Traditional groups. In the NS 1 course at Lemoore, the NMIS group's score increased 32.8 percent, whereas the Traditional group's score increased 13.5 percent. At Sanger, the NMIS group's score was up 23.1 percent, and the Traditional group's score increased only 15.9 percent. In Sanger's American Government course, the NMIS group's score improved 29.7 percent, but the Traditional group's score declined 7.3 percent.

These findings support the assertion that the NMIS makes a positive difference in students' achievement. Moreover, the findings in the NS 1 course at Sanger suggest that the NMIS is equally effective for groups of students who read with different levels of proficiency. On average, Hispanic students scored significantly lower than did students of other ethnicities on the CAT/5 reading scale; in addition,

Hispanic students in the NMIS group had lower scores, on average, than did Hispanic students in the Traditional group. Even so, the scores of the Hispanic students in the NMIS group increased 23.4 percent from pre-test to post-test, a slightly higher gain than was achieved by other students in the NMIS group. In contrast, the scores of Hispanic students in the Traditional group increased only 15.5 percent, comparable to other students in the Traditional group.

The improvement in the students' scores during this study from the pre-test to the post-test suggests that the NMIS "raises the floor" to some minimum level of achievement. It can be posited that this outcome can be explained by learning theory (Kaput, 1989). That is, multiple representations of material promote better retention on the part of students, and, as described above, students in NMIS classrooms hear the lesson delivered orally, see the material presented visually, and, concurrently, take notes on the material manually (by typing on a keyboard).

However, the findings may be explained other ways. We did not identify pre-test and post-test scores by student (to protect students' privacy), and, although the rate of attrition was comparable in both groups at both schools, a disproportionate number of students with low pre-test scores may have dropped from the NMIS groups before the post-test. Eliminating them from the post-test would have raised the groups' scores regardless of the efficacy of the system (assuming that these students' post-test scores would have been low relative to the other students' scores).

It also is possible that there may have been an "instructor effect" at Sanger where one instructor taught the NMIS sections of the NS 1 and American Government courses while other instructors taught the Traditional sections. However, the difference in the achievement of the NS 1 groups at Lemoore cannot be attributed to an instructor effect because the same person taught all four sections of the course. It is possible this individual's level of energy varied during the day (the Traditional group was taught during the last class period), but, during our visits to the classes, we did not observe any indication that this might be the case.

On the other hand, it is possible that the effect of the NMIS on students' scores is understated in this study. If the period of study had

been longer, the difference between the groups' scores might have favored the NMIS group even more strongly. There are two principal reasons:

First, the system was new to the students and, indeed, to one of the instructors using it as well. In general, students stated during the focus groups that the system was easy to learn, but they also said it got easier to use as they gained experience with it. Students may have been building system-related skills during much of the approximately ten-week period that elapsed between the pre-test and the post-test. They may have been using the system effectively only near the end of this study.

Second, there may have been a "ceiling" on the range of the NS 1 test scores because the first ten weeks of the course may have covered material that was already known to the students or was learned relatively easily by them.[1] It is likely that the range of variation in the scores would have been greater had this study extended over a longer period, so that the test could have covered more extensive and, perhaps, more challenging course material.

The findings relative to the American Government course are indeed surprising. The improvement of the NMIS group's scores from pre-test to post-test is consistent with the improvement of the NMIS groups in the NS 1 course. However, it seems highly unusual that the scores of the students in the Traditional group would decline from pre-test to post-test. One plausible explanation is that students who made high scores on the pre-test transferred out of the Traditional sections. A second possible explanation is instructor effect. A third possible explanation was offered by the instructor of the Traditional group who said that students do not do well on tests that are not part of their course grade. "They probably weren't motivated because

[1] The relatively high scores on the NS 1 pre-test suggest that some of the material was familiar to students. During the focus groups, students commented that the pre-test and post-test were not easy. However, many of the students replied that they had family members in naval or military service. It is possible that these students learned some of the course material through association with family members. During a focus group session, one student commented in reference to an NS 1 class that was taught with traditional methods of instruction during a previous school year, "Over half of the book was boring. It was easy to read, but you didn't want to read it. It was clear and well organized. But you could answer the questions without reading it."

they weren't accountable." However, this explanation is not wholly satisfying because the scores of only one group declined, but all of the students participating in this study were told at the start of each test that their score would not affect their course grade. A fourth possible explanation might be inferred from the fact that the students in the NJROTC section of the American Government course were self-selected. As noted above (Chapter Four), students competed to be in the NJROTC section. This fact can be interpreted two ways. On one hand, a non-NJROTC instructor volunteered, "Kids take that [NJROTC] class because it's easier. There's no homework. They study less material. I make them think. There, it's rote learning. That's not what they need for college." On the other hand, anecdotal evidence suggests that achievement-oriented students enroll in NJROTC (see the subsection "Attract More and Better Students," Chapter Five). In addition, a student commented that students choose the NJROTC section of the American Government course because it is more interesting, covers more material, and equips them with skills they expect to use in the future.

THE NMIS SHAPES USERS' BEHAVIORS

It also can be argued that the system predisposes its users to behaviors (such as taking notes on course materials and lectures) that facilitate learning. It does this by providing rewards, by imposing constraints, and by freeing users from limitations that are inherent in traditional classroom settings.

For example, instructors use the testing module of the NMIS because, among other reasons, it scores tests and eliminates many hours of tedious work. They adhere to the lecture outline, apparently, because it is readily available, it is helpful, and students expect them to follow it. Instructors said they like to use the NMIS because it frees them from the blackboard and media devices at the front of the classroom, and, thereby, enables them to walk around the room during their lecture, monitor the class, and assist individual students more fully than in traditional classroom settings.

Students tend to look up definitions in NMIS course materials because the hypertext links are easy and "fun" to use. They tend to refer back to points they missed during a lecture because they can easily "scroll" the Instructor's Notes. In contrast, they reported that in

traditional class settings they generally do not make the effort to look up unfamiliar words or follow up on a missed point. During most of the class period, students remain seated at their desks, at work on assigned tasks, in part, we suggest, because the system conducts an active "dialog" that is engaging and motivating, and in part because the students expect to be held accountable—in classes using the NMIS, it is readily apparent who is not taking notes, and students know their instructors are able to review their work more easily than teachers in non-NMIS classes. Similarly, the "Jeopardy Game" engages students during the discussion period because it is "fun" and because they are aware that each of them has an equal chance of being called upon to answer a question. Students reported that they prefer to take tests using the NMIS because they value the immediate feedback it provides, and, indeed, that feedback appears to be a source of positive reinforcement.[2]

The ability of the system to shape its users' behaviors has positive implications. Presumably, "canned" lectures can be developed that would ensure that lessons are delivered with a minimum level of proficiency, almost regardless of an instructor's professional skill and/or level of motivation.[3] Similarly, it may be possible to develop new ways for students to interact with the system; ways that would engage the students more fully in the curriculum.

OPPORTUNITY FOR PEDAGOGICAL INNOVATION

In discussions with instructors who were using the system and in our observations of classes, we noted that classes using the NMIS follow a traditional didactic instructional approach. That is, although the NMIS functions to some extent as a tool for more effective class management, it has had relatively little effect on pedagogy, and instruction remains primarily teacher-centered.

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[2]During our observations of the classes, we noted that students appeared to be actively engaged by the system. For example, the immediate feedback provided by the testing module elicited exclamations (which, usually, the students made softly to themselves) such as, "'B'—of course!" and "I knew it was 'D'!" Many students also responded to the feedback with "body English."

[3]It is assumed that instructors could enhance the "canned" lectures by tailoring them to their individual preferences and incorporating supplementary materials.

Students do not use textbooks, but they do read material on their computers that has been scanned into the system from traditional textbooks.[4] Instructors rely mainly on a lecture format to deliver information. They use the NMIS to organize lecture information for the students and help them stay on track (through the mechanisms of lecture outlines and note-taking templates).

Cuban (1988) notes that successful school reforms generally incorporate changes that "try to make what already exists more efficient and more effective." The NMIS may be effective because instructors use it to improve the delivery of curriculum in a familiar, traditional fashion. Taking a longer view, we question whether it is also possible to take advantage of the potential in the system to make learning more student-centered and teach students how to be more responsible for their learning. Reference, for example, the initiatives of the Institute for Learning Technologies, Teachers College, Columbia University, which are designed to enable students to access teaching resources independent of teachers (Columbia, 1995a). Also reference "The Edison Project," which is being used in the Chemistry Department at Columbia with the basic premise that "students should be actively involved in their own education. 'We want to challenge and change the time-honored format of the professor who stands at the blackboard, with knowledge passing in one direction'" (Columbia, 1995b).

We question, for example, whether the study skills students use with the system (e.g., taking notes in outline form, referring to notes while writing essays) transfer to other subjects, or whether they relieve students of learning to apply the proper organizational structures to their work. Are there coaching strategies (cf. Brown et al., 1988) that might be introduced as students grow familiar with the system to ensure that they assimilate the study skills and make them a natural part of their study habits?,

Another concern we have is that the system has yet to fully access the information resources that are available to students electronically

[4]However, the NMIS course materials are not merely scanned versions of the textbooks. For example, the system includes hypertext links that connect words in the text to the glossary. This mechanism, as noted above, increases the likelihood that students will look up unfamiliar words.

(e.g., books, articles, films, documentaries, and personal interviews via the Internet and on compact disks), and help students acquire the personal command of information that is becoming a mandate in modern society. Linking the NMIS with the Internet opens myriad possibilities for students to access and apply information. To take advantage of this opportunity requires what Cuban (1988) labels "second order changes" which "introduce new goals, structures, and roles that transform familiar ways of doing things into new ways of solving persistent problems." Instructors would need to rethink their roles in the classroom, the organization of their curricula, and the structure of their teaching.

Second order changes are difficult to accomplish and require new problem definitions and solutions, but we believe they offer substantial benefits in equipping students with skills that they will need in the future.

THE IMPORTANCE OF SYSTEM IMPLEMENTATION AND SUPPORT

This study did not investigate in depth the motivation, training, and on-going support provided to users. However, students' and instructors' comments indicate that implementation issues are likely to be critical to the success of the system at other NJROTC locations.

Information systems literature explains that users' decisions whether to adopt a system are influenced by their initial perceptions of it (Lucas, 1981), and these perceptions are strongly influenced by users' individual characteristics (Devin, 1994). In other words, a systems' objective costs and benefits may be less important than the users' subjective perceptions of them. Typical of users in general, NMIS users appear to have had polar impressions of the system.

> You see a computer, you say it's going to be fun, not a boring lecture.

> Initially, it might look as though it burdens one. Once you understand it, then it eases the teacher's workload.

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The first hurdle is to get prospective users to try a system. Studies show that users' perceptions are influenced by advertising, their perceptions of peers' experiences with the system or a comparable system, etc. (cf. Devin, 1994).

The second hurdle is to implement the system in a manner that increases the likelihood that users' initial experiences with it will be positive. This phenomenon is explained in the literature (cf. Devin, 1994); the practical consequences are described eloquently by an instructor and a student who participated in this study:

> A board, markers, and erasers never fail you. When the system hiccups, you need proper support or you'll say, "That's all I needed. I'll never let it do that to me again!"

> I mess around on the computer at home, and it gets old getting trapped [by a system fault], and not being able to get out. When you do, you don't want to touch it again. You distrust it.

As the first quote indicates, one way to ameliorate the frustrations that often are encountered by new users is to provide adequate ongoing support. It will be recalled that instructors themselves commented on the importance of system support (see the subsection "Would Instructors Recommend the NMIS to Other NJROTC Units?" Chapter Five).

We suggest that the vehicle used for system support might also be used beneficially to promote and disseminate innovations. In general, users employ a system at first as a substitute for a procedure with which they are familiar, then, as they gain experience with it, they discover new ways to use it (cf. Pape and Thoresen, 1990; Sandstrom, 1987; Szlichcinski, 1983). Consistent with this phenomenon, we observed that students and instructors appeared to integrate the NMIS more fully into their work as they gained familiarity with it. In the main, students' innovations appeared to be related to extracurricular activities. Instructors were taking steps toward new approaches to teaching. For example, they found with the NMIS they could walk around the classroom and interact more effectively with students than when they used traditional methods of instruction. They found that the sound of typing—both continuous typing and the absence of typing—indicates whether students' understand

and/or are attentive to the lecture, and they adjust the pacing of the lesson accordingly. We applaud these steps, and we suggest, as discussed above (see the subsection "Opportunity for Pedagogical Innovation," Chapter Six), that important innovations are likely to be found by exploring new approaches that enable and encourage students to use the NMIS to a larger extent on their own initiative.

Chapter Seven

CONCLUSIONS

The data collected during this study indicate that the NMIS has positive effects on students' achievement, on their attitudes, and on instructors' workload. Our interpretation of the data suggests that there exists a tight interweave among the students' academic achievement, their attitudes toward their courses, and the instructors' workload.

It appears that the NMIS is efficacious because it facilitates the use of methods of instruction that educators have found to be effective—methods (such as using multiple media, providing immediate feedback, and helping students individually) that often are difficult to apply in classrooms today because of large class sizes, administrative burdens placed on teachers, reliance on teaching tools that are inconvenient to use, and challenging academic skills, expectations, and behaviors of many of the students. The system also appears to be effective because it engages students interactively, and, in the process, it transforms tasks that students find onerous in traditional classes into game-like activities.

IMPLICATIONS FOR CNET

In this concluding chapter, we discuss the potential for extending the use of the NMIS beyond its current applications. The cost of hardware, software, and training is, of course, a primary consideration in the decision whether to expand the use of information technology in the NJROTC curricula; but, in addition, we suggest that the evaluation should also weigh the value of the following implications of the system.

A Virtual Presence in NJROTC Units

NMIS technology enables CNET to maintain a "virtual presence" in NJROTC classrooms and, thereby, "raise the floor" for academic achievement to some minimum level, particularly at locations where students require remedial assistance. The four principal enablers are the Instructors' Notes component of the system, course supplements containing current material, tests, and "portfolio" sampling.

Instructors' Notes encourage instructors to deliver the curriculum in a consistent and professional manner that incorporates multi-media. We posit that many NJROTC instructors are likely to follow the Notes more closely than hardcopy course materials because the Notes require minimal preparation on the part of the instructors. The Notes may be particularly helpful to individuals who have not taught high school students previously. They also may serve to motivate more experienced instructors who are experiencing "burn out." Yet, they can be tailored by innovative instructors.

From many students' perspective, out-of-date course material often implies that a course is not relevant and, consequently, not worth their attention. Although it is difficult and expensive in a rapidly changing world to maintain up-to-date hardcopy texts and materials, it is relatively easy and inexpensive to revise and supplement[1] NMIS courses electronically (via the Internet, email, or diskettes). Instructors could incorporate electronically transmitted updates into their courses with relatively little effort.

CNET could distribute tests electronically to NJROTC units. The tests could cover the core concepts that CNET determines instructors should teach in a course, and they could be issued immediately before being given in order to minimize "teaching to the test." The tests would be scored by NMIS software, and the results, by student, could be forwarded electronically to CNET. A program at CNET could consolidate the data, analyze it, and compare students' achievement by NJROTC unit. This technique would enable CNET to

[1]A Naval Science Instructor suggested that items of interest to NJROTC students could be distributed via the Internet in the same manner that the Navy (OPNAV) distributes the "Yellow Sheet" via electronic mail to inform personnel of key articles appearing in major newspapers.

evaluate the effectiveness of the instruction at each unit using objective statistical techniques similar to those used in conjunction with national tests such as the SAT, GMAT, LSAT, etc.

The NMIS enables CNET to evaluate the curriculum and the NJROTC units' performance in new ways. For example, it might borrow from the "portfolio assessment" method that has been adopted by various school districts, and randomly sample and review the files that contain students' reading and lecture notes, essays, and homework. This "assessment" might be done, at least in part, by a computer program that would automatically draw files at random from NJROTC sites and compile statistics about them.

An Opportunity to Promote Pedagogical Innovation

As we have suggested in this report, the NMIS creates an environment that is conducive to innovation. CNET might use the system as a platform for pedagogical innovation that could "raise the ceiling" for academic achievement and effectively challenge learners with differing levels of ability. It appears that innovative use of information systems technology would enable NJROTC units to serve as a role model for other departments of their schools, and enhance NJROTC interaction with the school community. Anecdotal evidence suggests these initiatives would also serve to help attract more and better students to the NJROTC program.

Potential Cost Savings

We did not investigate issues relative to the logistics of publishing and distributing course materials. However, the NMIS technology would enable CNET to publish and distribute "courseware" electronically (and update the materials, as well, as discussed above). It is probable that the costs associated with electronic courseware would be markedly less than the costs associated with traditional textbooks, etc. Indeed, electronic publishing and distribution may offset, to a significant degree, the cost of the system.

SUGGESTIONS FOR FUTURE RESEARCH

As stated above, this was an exploratory study. The findings indicate that a more rigorous study of the NMIS would be worthwhile. Such a study would identify the "critical success factors" for the NMIS in terms of the:

1. Training and technical assistance needs of users (both students and instructors),
2. Implementation requirements, particularly in educational settings where the students, instructors, and infrastructure differ from those at Lemoore and Sanger, and
3. Human/computer interface factors that help users learn and use the system.

Learning more about the training and technical support needs of NMIS users (both students and instructors) would be a valuable aid to designing effective implementation procedures.

A related research agenda concerns hardware and software, i.e., whether other configurations of the system might improve its price/performance ratio.

Appendix A

THE NMIS CLASSROOM

The NMIS classrooms at Lemoore and at Sanger differ somewhat; Figure A.1 shows a general schematic of the installations.

A television monitor is located at the front of the room; the large screen ("home theater" size) enables all of the students in the classroom to see the material displayed on it.

The instructor's workstation, also at the front of the room, includes a computer (i.e., computer, monitor, keyboard, and mouse), videocassette player, laser disc player, and a switch that connects the output

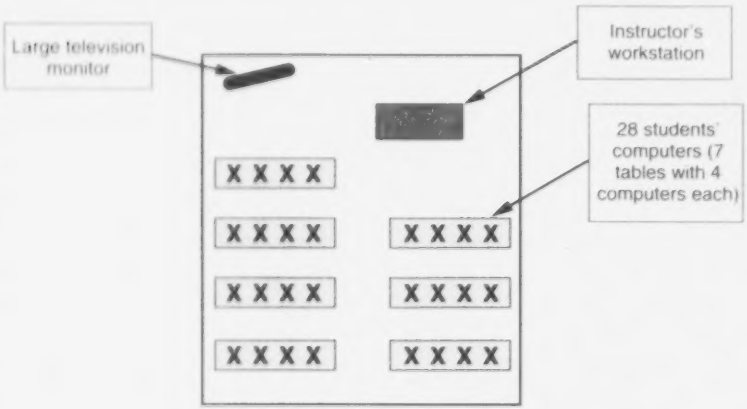

Figure A.1—Diagram of a Typical NMIS Classroom

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from either the video or the laser disc player to the television monitor. The instructor's machine has supervisory control over the students' machines, that is, instructors can download/upload material to/from the students' machines, and they can lock the students' keyboards.

The students' machines sit four to a table on seven tables, which are approximately eight feet long by two feet wide. At both schools, the care with which the equipment and the classroom are maintained is readily apparent to students and visitors alike (cf. the subsection "Impact of the NMIS on School Culture," Chapter Five). The computers are aligned in precise rows. When they are not being used, the keyboards are tucked neatly under the overhang of the monitor, and the mice (most of them), are placed just to the right of the keyboard. Students are expected to return their equipment to this position at the end of the class. Instructors check the equipment daily for damage. Comments made by at both schools by NJROTC instructors, school administrators, and students suggest that it is because of this discipline that the NJROTC NMIS classrooms have fewer maintenance problems and are more enjoyable to use than the computer labs in other departments of the schools.

Extensive remodeling was not required for the installation. Cables connecting the students' machines to the power source and the instructors' computer are tied underneath the tables, largely out of sight, and continue along the walls, relatively inconspicuously.

Appendix B

RESULTS OF THE NAVAL SCIENCE 1 TEST AT LEMOORE

The pre-test was taken by 81 students. The post-test was completed by 79 students.

Students in the NMIS group scored, on average, 31.7 points on the pre-test, and students in the Traditional group scored 37.9 points. The difference in the groups' pre-test scores is highly significant ($p = 0.0002$). That is, the probability is zero that the scores of two groups are from the same population.

The average score on the post-test was 42.1 for the NMIS group and 43.0 for the Traditional group. The difference in the post-test scores is not statistically significant ($p = 0.6390$). In other words, the groups were relatively comparable in terms of their post-test scores.

During the term, the average score of the NMIS group increased 32.8 percent (i.e., up 10.4 points, from 31.7 to 42.1) whereas the average score of the Traditional group increased 13.5 percent (i.e., up 5.1 points, from 37.9 to 43.0). The 6.2 point "advantage" of the Traditional group on the pre-test (37.9 versus 31.7) was narrowed to 0.9 point on the post-test (43.0 versus 42.1).

There is no significant difference in the Lemoore students' scores on the NS 1 test when the scores are partitioned by school year within group, or by gender within group. The scores of the Hispanic students at Sanger, on average, were lower than those of other ethnic groups on the pre-test and the post-test. It is not meaningful to partition the Lemoore data by ethnicity within group because there

were not sufficient numbers of students in each category to provide statistical reliability.

Figure B.1 shows the distribution of pre-test and post-test scores. Four graphs are shown. The two topmost graphs illustrate the distribution of the pre-test scores for the two groups: The NMIS group is on the left side of the figure and the Traditional group on the right side. Scores are shown with a histogram, where the bars cover the five-point intervals that are displayed on the horizontal axis. The vertical axis indicates the percentage of the group in a given interval. For example, approximately 36 percent of the students in the NMIS group had pre-test scores between 30 and 35 points. A normal curve has been fitted to the data and is superimposed on the histogram. A vertical line marks the mean of the distribution.

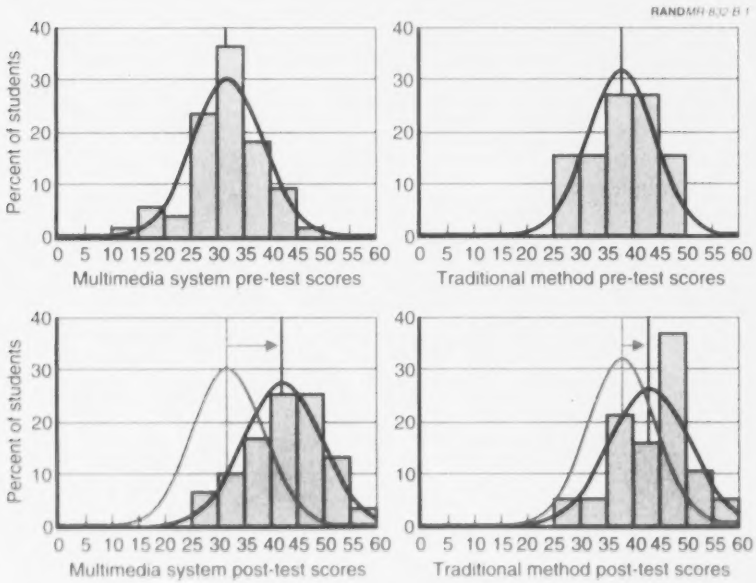

Figure B.1—NS 1 Pre-Test and Post-Test Scores at Lemoore High School

The two lower graphs show the distribution of the post-test scores for the two groups. The NMIS group is on the left and the Traditional group is on the right. For ease of comparison, the bottom graphs show a gray vertical line and a gray curve which represent the group's pre-test mean and normal distribution.

The graphs illustrate that (1) the Traditional group had higher scores on the pre-test, (2) scores for both groups improved from the pre- to the post-test, and (3) the scores of the NMIS group improved more than did the scores of the Traditional group, i.e., the curve of the NMIS group shifted a greater distance to the right.

Appendix C

RESULTS OF THE NAVAL SCIENCE 1 TEST AT SANGER

The pre-test was taken by 104 students, and 83 students took the post-test. The same NS 1 tests were used at both Sanger and Lemoore, but scores for Sanger should not be compared directly with scores for Lemoore because somewhat different material was covered at the two schools.

The average test scores on the pre-test were 33.7 for the NMIS group and 33.4 for the Traditional group. The difference is not statistically significant ($p = 0.8672$).

The average scores on the post-test were 41.5 for the NMIS group and 38.7 for the Traditional group. The difference is statistically significant below the 10 percent level ($p = 0.0679$). In other words, there is a less than 10 percent probability that the 2.8 point margin favoring the NMIS group is a chance event.

The average score in the NMIS group increased 23.1 percent (7.8 points) from the pre-test to the post-test. The Traditional group's average score increased 15.9 percent (5.3 points).

There are no statistically significant differences in the NS 1 test scores by grade level or by gender within the groups. Table C.1, below, reports that the NS 1 test scores of the Hispanic students in the NMIS group increased 23.4 percent from the pre-test to the post-test, slightly more than the 22.1 percent increase in the scores of the other students in the NMIS group. In contrast, the scores of the Hispanic students in the Traditional group improved 15.5 percent, a rate comparable to that of the other students in the Traditional group.

Table C.1

Sanger NS 1 Scores by Ethnicity

Group	Subgroup	Pre-Test	Post-Test	Change	
NMIS	Hispanic	32.07	39.59	+7.52	23.4%
	All other	36.21	44.20	+7.99	22.1%
	total	33.71	41.46	+7.75	23.0%
Traditional[a]	Hispanic	30.96	35.75	+4.79	15.5%
	All other	36.20	41.82	+5.62	15.5%
	total	33.45	38.65	+5.20	15.5%

[a]Data are incomplete regarding the ethnicity of some students in the Traditional group who took the pre-test. These data have been estimated in part.

Figure C.1 shows the distribution of pre-test and post-test scores. Four graphs are shown. The two topmost graphs illustrate the distribution of the pre-test scores for the two groups: The NMIS group is on the left side of the figure and the Traditional group on the right side. Scores are shown with a histogram, where the bars cover the five-point intervals that are displayed on the horizontal axis. A normal curve has been fitted to the data and is superimposed on the histogram. The vertical axis indicates the percentage of the group in a given interval. For example, approximately 20 percent of the students in the Traditional group had pre-test scores between 40 and 45 points.

The two lower graphs show the distribution of the post-test scores for the two groups. The NMIS group is on the left and the Traditional group is on the right. For ease of comparison, the bottom graphs show a gray vertical line and a gray curve which represent the group's pre-test mean and normal distribution.

The graphs illustrate that (1) the groups' pre-test scores were comparable, (2) scores for both groups improved from the pre- to the post-test, and (3) the post-test scores of the NMIS group improved more than did the scores of the Traditional group, that is, the curve for the NMIS group shifted further to the right than did the curve for the Traditional group.

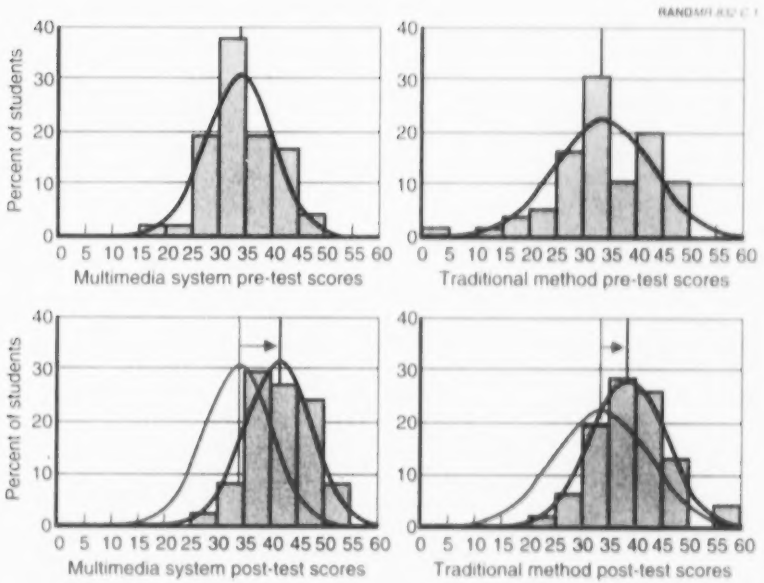

Figure C.1—NS 1 Pre-Test and Post-Test Scores at Sanger High School

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Appendix D

RESULTS OF THE AMERICAN GOVERNMENT TEST

The pre-test included 94 students and the post-test included 82 students.

The average score of the NMIS group on the pre-test was 17.2. The Traditional group's average score was 19.2. The difference is statistically significant below the 10 percent level ($p = 0.0796$).

On the post-test, the NMIS group's average score increased 29.7 percent (5.1 points). The Traditional group's average score decreased 7.3 percent (–1.4 points). The difference is statistically significant ($p = 0.0015$).

There are no statistically significant differences in the test scores when they are partitioned by gender or ethnicity.

Figure D.1 shows the distribution of pre-test and post-test scores. Four graphs are shown. The two topmost graphs illustrate the distribution of the pre-test scores for the two groups: The NMIS group is on the left side of the figure and the Traditional group on the right side. Scores are shown with a histogram, where the bars cover the five-point intervals that are displayed on the horizontal axis. A normal curve has been fitted to the data and is superimposed on the histogram. The vertical axis indicates the percentage of the group in a given interval. For example, approximately 43 percent of the students in the NMIS group had pre-test scores between 15 and 20 points.

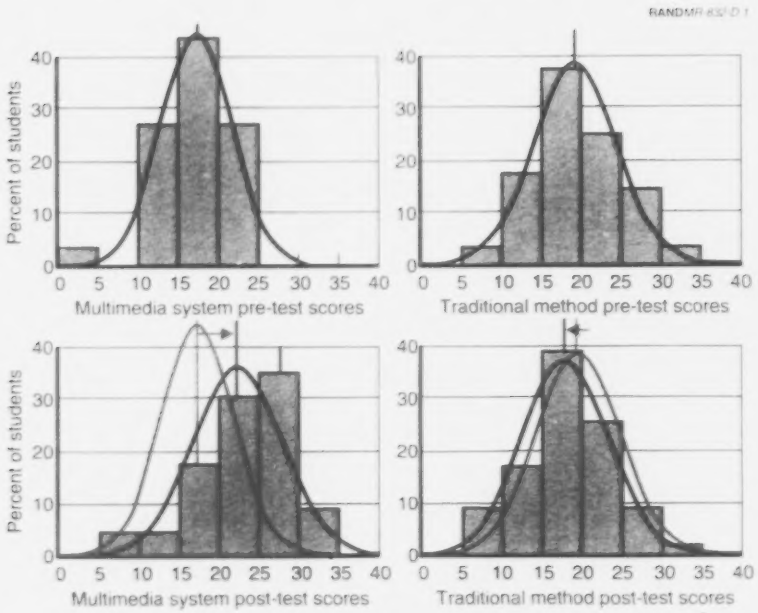
RAND MR 653-D.1
Percent of students
Multimedia system pre-test scores
Traditional method pre-test scores
Multimedia system post-test scores
Traditional method post-test scores
0 5 10 15 20 25 30 35 40
0 10 20 30 40

Figure D.1—American Government Pre-Test and Post-Test Scores at Sanger High School

The two lower graphs show the distribution of the post-test scores for the two groups. The NMIS group is on the left and the Traditional group is on the right. For ease of comparison, the bottom graphs show a gray vertical line and a gray curve which represent the group's pre-test mean and normal distribution.

The graphs illustrate that (1) pre-test scores were higher for the Traditional group than the NMIS group, (2) post-test scores of the NMIS group are higher than its pre-test scores, and, in fact, are skewed toward the higher end of the scale, but (3) post-test scores of the Traditional group declined from the pre-test level while maintaining, approximately, the same distribution, which suggests there is no anomaly such as the top students leaving the class.

TASKS STUDENTS MUST LEARN TO USE THE NMIS

- Tasks to read course material
  - — Bring up menu bar
  - — Use scroll bar
  - — Click highlighted text to bring up pictures, notes, definitions
  - — Go to next page
  - — Go to a specific page in a document
  - — Return to main folder
- Additional tasks to write notes and answer the questions at the end of each unit
  - — Copy from a HyperCard file
  - — Paste into a Claris Works file
  - — Use the tab to make an outline
  - — "Find" text in a document
- Additional tasks to write essays using the notes file(s)
  - — Use a split screen
  - — Be able to highlight a window
- Additional tasks associated with tests
  - — Enter the test program

  - Click answer
  - "Mark" an answer
  - Go to next question
  - Return to prior questions that were not answered
  - End test
- Optional, advanced skills[1]
  - Create and use a HyperCard stack
  - Use the HyperCard tool box
  - Make HyperCard buttons and fields
  - Use the scanner and, perhaps, telecommunications software

[1]These skills are acquired by students who elect to use the NMIS to give presentations, e.g., to report a team project to the class. Typically, they are obtained via coaching by the instructor and/or trial-and-error practice.

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